On the quality of ENSDF γ-ray intensity data for γ-spectrometric determination of Th and U and of disequilibria in their decay series, in the assessment of the radiation dose rate in luminescence dating of sediments

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Advanced thermally and optically stimulated luminescence (TL, OSL) dating protocols are becoming prominent geochronometric tools for the age determination of sediments [1,2], expected to lead — for aeolian loess deposits — to a significantly enhanced knowledge in the fields of palaeoclimatology and -ecology. In luminescence dating, the radiation dose rate should be reliably known, its uncertainty being linearly propagated to the age result. Among the techniques used for dose rate determination [3], a special role is played by Ge γ-ray spectrometry of the sediment. It not only yields the content (and thus the dose rates) of the radioelements K, Th and U, but it also allows measuring ^{228}Ac, ^{224}Ra, ^{212}Pb and ^{208}Tl in the ^{232}Th decay series, and ^{234}Th, ^{214}Pb, ^{214}Bi and ^{210}Pb in the ^{238}U series. This provides information on the occurence — in geological times — of possible disequilibria, which are especially likely in the ^{238}U series due to ^{226}Ra-mobility (for which ^{214}Pb and ^{214}Bi are the indicators) and/or ^{222}Rn-emanation (with ^{210}Pb as the indicator). Such disequilibria — if significant — are deteriorating the accuracy of the radiation dose rate estimation and hence of the dating result.

In the present work, the performance is examined of two methodological variants of the γ-spectrometric analyses, which are largely depending on the quality of the nuclear decay data involved. Firstly, the possibility is investigated of a parametric calibration of the sediment measurements. Evidently, this requires the detection efficiency (together with coincidence summing effects) to be reliably known, and furthermore its accuracy is depending on the γ-ray intensities to be introduced. Actually, a parametric calibration could be preferred to the usually applied relative one with K/Th/U standards, which should be remeasured for each new sample geometry, and the composition and packing density of which are occasionally not matching those of the samples, thus necessitating a detection efficiency conversion anyhow. The second one concerns the check of the ^{226}Ra disequilibrium. Although, as said, this can be based on ^{214}Pb and ^{214}Bi, the latter can also be formed via decay of ^{222}Rn surrounding the Ge-detector (unwanted, and usually flushed with N_2 from the Dewar). Therefore, an interesting alternative would be to directly measure the ^{226}Ra 186.1 keV γ-ray, an intense line in the spectrum, which is however heavily interfered by ^{235}U at 185.7 keV. In principle, corrections can be made via other lines in the spectrum (some involving second-order corrections), thus relying on the introduction of γ-ray intensities (next to detection parameters), the quality of which is largely influencing the reliability of the result obtained.

The above-described methodologies were examined via the measurement of several loess and sand sediments, and with introduction of γ-ray intensity data originating from ENSDF (via Isotope Explorer [4]). Relevant conclusions could be drawn as to the accuracy of the data and their quoted uncertainties, and — as a feedback to the experimentalists and evaluators of the nuclear data under study — some recommendations could be formulated.

[1] A.S. Murray and A.G. Wintle, Radiation Measurements 32 (2000) 57.
[2] T. Watanuki, A.S. Murray, S. Tsukamoto, Quatern. Sci. Revs 22 (2003) 991.
[3] S.M. Hossain, F. De Corte, D. Vandenberghe, P. Van den haute, NIM A 490 (2002) 598.
[4] Isotope Explorer 2.23, January 28, 1999.

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